BULLETIN
OF THE
TORREY BOTANICAL CLUB.

Vol. X.] New York, April, 1883. **[No. 4.**

Notes on the Haustoria of some N. A. Parasitic Phanerogams.

By Jos. Schrenk.

(Plates XXXI–XXXIII.)

Comandra umbellata, Nutt.—The following description of the haustorium of *Comandra* is based on specimens that grew on the roots of *Aster Tradescanti*, L. The figures on the accompanying plates (except Fig. 5), were all drawn from such haustoria; those from other dicotyledonous foster-plants, however, are not at all essentially different. In Figs. 3, 6 and 8 the *outlines* of the various tissues are magnified 80 times, while the individual cells are made to represent the type of those tissues by employing higher powers. In the figures of the other sections the cells appear magnified about 500 times, and the perspective illustrations of the entire haustorium with its foster-root, Figs. 1*a*, 1*b*, and 2*a*, 2*b*, 8 and 12 times respectively. For the sake of brevity, I shall, with reference to the foster-root, call the sections represented by Figs. 3, 6 and 8 respectively, the longitudinal, the transverse, and the tangential (the last being a cross-section of the haustorium itself).

The *haustoria* (suction-organs) of *Comandra* grow on thin, short branches of the root, and usually appear as if stalked. Sometimes they seem to be terminal (Fig. 2*a*), but their internal structure, as well as the common mode of their growth, illustrated by Fig. 1*a*, show that they are lateral organs. The rootlet bearing the haustorium may run parallel with the foster-root (Fig. 1*a*), or in a different direction (Fig. 2*a*). The form of the haustoria is half-ellipsoidal or bell-shaped, somewhat laterally flattened, the longer diameter of their cross-section being parallel with the axis of the foster-root. Their size varies according to age and other circumstances. The smallest are quite minute; the ones figured on the plates (a little over 1$^{mm.}$ high and about 1.5$^{mm.}$ wide), I found to be of a common size, but there are some that are twice as large, or even larger.

Viewed externally, the haustorium appears to grasp the root of the foster-plant as a hand, deprived of its thumb, would grasp a large cylindrical object; or, still better, as one's lips would take hold of a finger-joint to suck the blood from a wound (Figs. 1*a*, 1*b*, 2*a*, 2*b*).

In describing the structure of the haustorium, we have to distinguish the interior tissues, which penetrate into the body of the foster-root, from the external covering. The latter, which we might call the *bark* of the haustorium (*bk* in all the figures), reaches from the top of the haustorium to the bark of the foster-root, which it partly encircles, thus playing the part of the lips in the above comparison. At its lower edge, we find a number of papillose cells, reaching, or

endeavoring to reach, the surface of the foster-root (Fig. 3). This "bark" consists of large, rounded, parenchymatous cells, which are usually distorted or torn at the outer surface, and in the vicinity of certain cavities, which will be mentioned hereafter. It is often formed of two or more shell-like layers, which grow successively longer, overlap one another, and thus make the surface of the haustorium appear as in Fig. 1*a*.

Under this outer covering there is a zone of oblong, prismatic cells, that are radially arranged in several close rows (*pc* in Figs. 3 and 6). This tissue does not penetrate into the foster-plant; we do not notice it in a tangential section taken as deep as the one in Fig. 8, but in sections higher up toward the top of the haustorium it is always seen encircling the central portion. Its peculiar cambium-like structure, and the manner in which the cells outside and inside of it seem to proceed from it, induce me to consider it as a kind of meristem from which, on one side, the bark (eventually with its successive layers) may originate, while on the other it may contribute to the development of the parenchymatous outer part of the central portion.

Very often there are empty spaces, caused by the stretching and tearing of the tissues, between the zone of prismatic cells and the bark (Fig. 6, *sp*), and also between the successive layers of the bark. Besides, an empty space is usually to be found extending along the curved surface of the foster-root, where the bark is attached by a few rows of cells only (Figs. 6, *sp* and 8, *sp*).

The *central portion* of the haustorium, which lies within the two zones described, and enters the body of the foster-root, consists of several distinct kinds of cells. Most conspicuous among them by their reticulated walls, their zigzag course and peculiar arrangement, are the vascular cells (*vc* in all the figures). They arise singly (Fig. 8), or in groups (Figs. 8 and 3), either at the apex of the haustorium, closely attached to the vessels of the foster-root, often even entering them, or at some distance from them. Continuing their course in zigzag lines they meet other vessels of the same kind, and unite with them in bundles, the butt ends of which form a rather compact ring in the centre of the haustorium. From the different groups of this ring, numerous *single* ducts proceed upward and converge into a large bundle, more or less distinctly divided longitudinally into two halves, and finally join the plerome of the *Comandra* rootlet (see Fig. 3, and for the upper half, Fig. 6). It usually happens that a zone around the lower part of the vertical axis of the haustorium contains no vessels. (Figs. 6 and 8). In Fig. 6, therefore, we see no vascular cells in the lower half, except a small portion of an arc (joining two groups of vessels) which was sliced off by the knife.

In the upper part of their course the vascular bundles are enclosed by a few rows of elongated, narrow prismatic cells (see Fig. 6), which are similar to the prismatic cells inside of the bark, but are much narrower and with thinner walls. There is little doubt that they perform the functions of the cambium of stems and roots.

Another kind of elongated (but not prismatic) active cells accom-

panies and surrounds the vessels in their lower course, where, in fact, they form the bulk of the haustorium (*ac* in all the figures). The transformation of these cells into vessels by the deposition of the reticulated thickening on the cell-wall, and the subsequent union of several cells into one duct, can be plainly traced.

The space in the central portion not occupied by the tissues mentioned is filled with a ground tissue of parenchymatous cells, not unlike those of the bark in form, but, for the greater part, of smaller size (*gt* in all the figures). In the lower half, especially in close proximity to the foster-root, these cells become also narrow and elongated. But at the two lateral extremities, where they curve outward to insert themselves longitudinally between and into the cells of the foster-root, many of them assume an inflated, club-shaped form (at *x* in Fig. 3, *gt* in Figs. 4, 8 and 10).

In all the sections we notice peculiar, striate bands dividing the parenchymatous tissue into shell-like layers (*ss*). Along these bands, cavities like those between the bark and the zone of prismatic cells are frequently met with, as in Figs. 3, 6, and 8. Similar structures were called "stripes of separation" by Solms-Laubach in his excellent description of the haustorium of *Thesium*, the Old World near relative of our *Comandra*.* Solms-Laubach has shown that they consist of parenchymatous cells, crowded together and crushed by the multiplying neighboring cells into a compact mass, in which the component individual cells are recognizable only with difficulty or not at all. As these notes are to furnish merely an anatomical description, I will reserve my opinion in regard to the origin of these "stripes," and will simply state that in *Comandra* they seem to be of a more complex nature than in *Thesium*; for, in the former, we find them not only in more or less concentric zones, as in *Thesium*, but every larger group of vessels with meristem tissue appears partly surrounded by such a shell of compressed cell-membranes.

The difference in the manner in which the cells of these two parasites are attached to those of their foster-plants deserves special attention. Solms-Laubach says (*l. c.* p. 545) that the terminal cells of the haustorium are *separated* from those of the foster-plant by an irregularly developed layer of a homogeneous, yellow mass, possessing high refractive power; and (p. 547) that this mass is evidently intended to *isolate* the haustorium from its foster-root, and that wherever this mass is but poorly developed or entirely wanting, the foster-root endeavors to replace it by producing a more or less massive corky layer. In the haustorium of *Comandra* I could detect no such mass nor any corky layer. Figs. 4, 5, 7, 9 and 10 show the points of contact in sections carried out in the three principal dimensions.

Fig. 4 is a longitudinal section, showing a group of cells from the vicinity of the point *x* in Fig. 3. Three cells, *gt*, belonging to what I have called the ground-tissue of the haustorium, enter some phloëm of the *Aster* root; the walls of all the cells can be plainly distin-

* Hermann Graf zu Solms-Laubach, über den Bau und die Entwickelung parasitischer Phanerogamen, in Pringsheim's Jahrb. für wissensch. Bot., Vol. vi.

guished without any intervening substance between them. The same is the case in Fig. 5, taken from a longitudinal section of a *Comandra* haustorium on a *Vaccinium* root. The location of this group of cells corresponds to the point *y* in Fig. 3. Here one cell of the parasite, having struck a tracheïd of the *Vaccinium* at right angles, has penetrated it, and within its cavity has formed a peculiar, capitate expansion. The other *Comandra* cells are about to break throngh the wall, while the adjoining cells of the foster-plant have already been partly disintegrated.*

Fig. 7 represents a cross-section of some vessels that have been entirely separated from the plerome of the *Aster* root by the rapidly growing apex of the haustorium, which, like a wedge, exerts a downward and sidewise pressure. Some of the cells (pitted vessels) are very much indented or compressed laterally. The same group, less magnified, will be found in Fig. 6, and another similar one, on the other side of the same haustorium. In this case, too, the cells of the parasite are seen in *close contiguity* with those of the foster-root.

Fig. 10, from a point *z* in the tangential section, Fig. 8, shows some cells of the parasite, that have descended vertically, and then have curved outward, to the right (compare Fig. 3), as they meet a large pitted vessel of the *Aster* and crowd into it, their walls closely pressing against those of the vessel. Some other descending cells are breaking the connection between this cell and the neighboring one.

A similar vascular cell of the *Aster* root, from a place corresponding to the point *w* in Fig. 8, but somewhat nearer to the apex of the haustorium, is shown in Fig. 9. It has been detached from the other vessels and is now wedged in between the actively growing peripheral and central cells of the interior haustorium. This figure, at the same time, explains the structure of the "stripe of separation," *ss*. We see the cells on both sides of it, but especially toward the circumference, yielding to the expansive force of the haustorium, and we can easily imagine that some of them will soon be totally crushed, and that their membranes will help to increase the mass of the "separation stripe." We also notice, at *bk*, some layers of bark-cells. They appear very much reduced in width, the innermost exceedingly so. Using a lens of lower power we might easily take this layer of partly and totally collapsed cells for the "homogeneous, yellow mass" spoken of above, especially after treating the section with alkalies for the purpose of making it transparent.

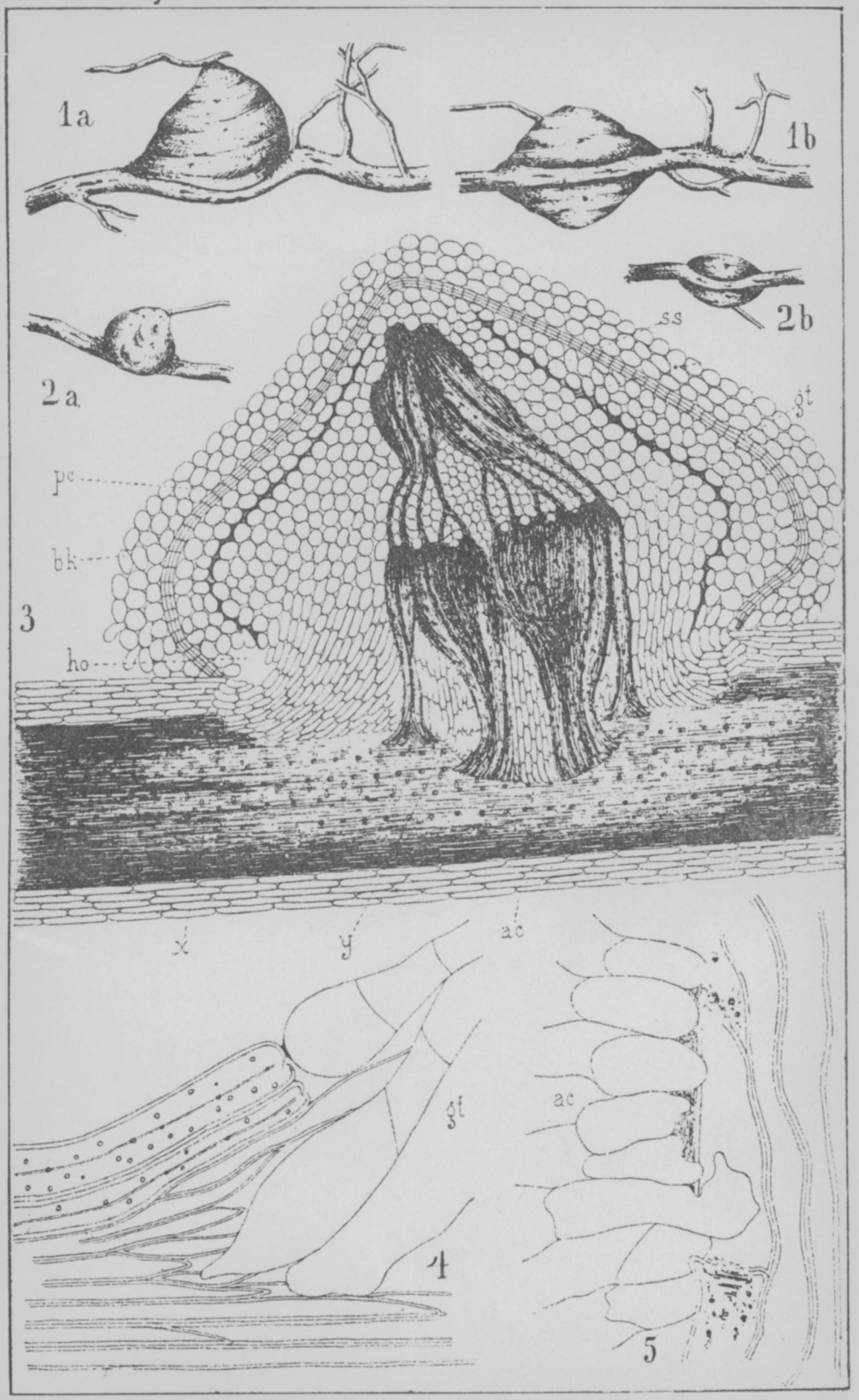
I think what I have said in explaining the five last figures will be sufficient to show that, in *Comandra*, there exists a direct and unobstructed communication between the cells of the haustorium and those of its foster-root.

Hoboken, March, 1883.

Aspidium Lonchitis, Swz.—The range for this fine fern is now extended to California, it having been collected by Mr. Pringle at Castle Lake, Siskiyou Co., September 5, 1882.

GEO. E. DAVENPORT.

* By the shading it is simply intended to show the wall of the tracheïd perspectively.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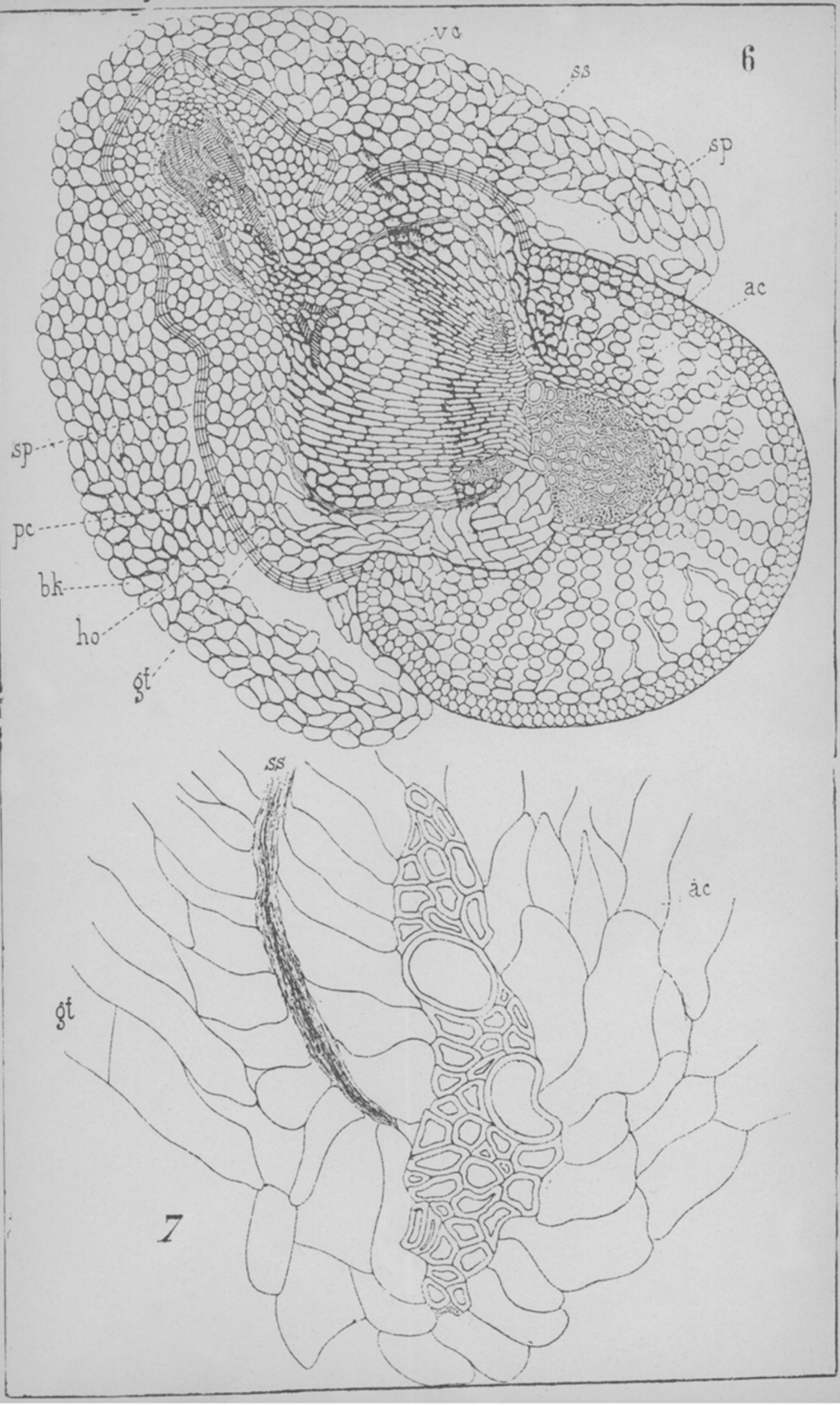
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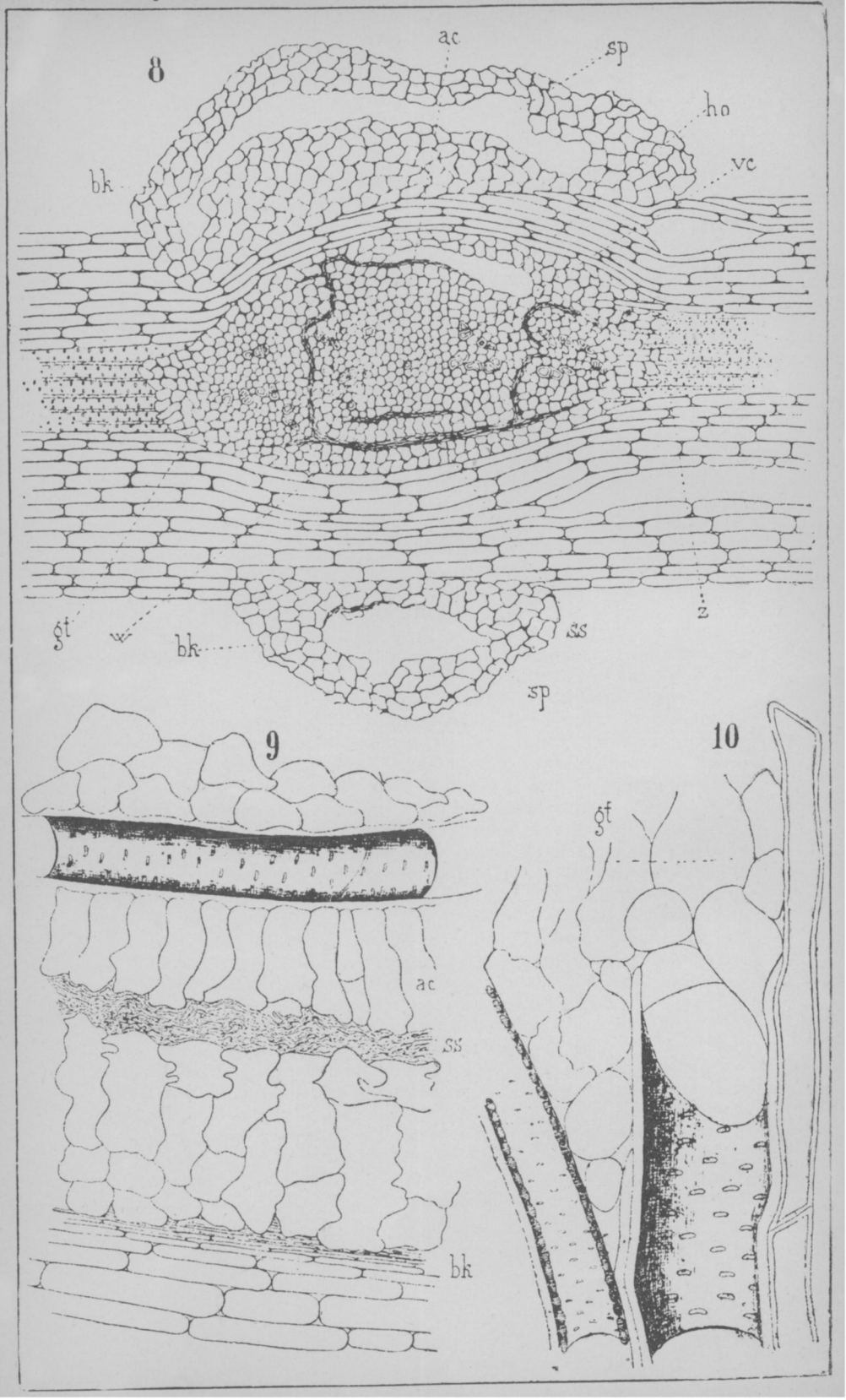
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